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SENSITIVITY OF DIVWAG TO VARIATIONS IN WEATHER PARAMETERS

by

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APRIL 1976

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: R-TR-76-009

2. GOVT ACCESSION NO.:

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): Sensitivity of DIVWAG to Variations in Weather Parameters

5. TYPE OF REPORT & PERIOD COVERED: Interim Report June 1975 - December 1975

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): Jerry W. Frantz, CPT Michael A. Roddy III, George E. Stiles, William A. Werker

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
Research Directorate SARRI-LR-S
GEN Thomas J. Rodman Laboratory
Rock Island, IL 61201

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 1W66260334H78

11. CONTROLLING OFFICE NAME AND ADDRESS:
Research Directorate SARRI-LR-S
GEN Thomas J. Rodman Laboratory
Rock Island Arsenal, Rock Island, IL 61201

12. REPORT DATE: April 1976

13. NUMBER OF PAGES: 20

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report):
Approved for Public Release
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):

18. SUPPLEMENTARY NOTES:

19. KEY WORDS (Continue on reverse side if necessary and identify by block number):
DIVWAG
WAR GAME
SIMULATION
MATHEMATICAL MODEL

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):
This is the second in a continuing series of reports on the application of DIVWAG at Rodman Laboratory. The first report primarily examines the model and its operational utilization at Rodman Laboratory. In this report, the sensitivity of the DIVWAG model to extreme changes in the weather environment is evaluated. Two extremes were examined: (1) optimum weather - clear daylight with no precipitation and (2) minimum weather - dark with heavy precipitation. These extremes were evaluated to determine the impact of weather variations on the target acquisition process and the mobility of maneuver units as simulated in

the DIVWAG model.

ACKNOWLEDGEMENT

The authors would like to thank Jolayne Yeager, Teresa Nicola, and Barbara Buranek for their assistance in preparing the manuscript in final form.

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TABLE OF CONTENTS

	PAGE
1.0 INTRODUCTION	1-1
2.0 CONCLUSIONS	2-1
2.1 Total Force Losses by Cause	2-1
2.2 Artillery Effectiveness	2-1
2.3 Target Acquisition	2-1
2.4 Ground Combat Engagements	2-2
2.5 Force Movement	2-2
3.0 DISCUSSION	3-1
3.1 Total Force Losses by Cause	3-2
3.2 Artillery Effectiveness	3-7
3.3 Target Acquisition	3-10
3.4 Ground Combat Engagements	3-13
3.5 Force Movement	3-14

The following page is blank.

LIST OF FIGURES

Figure		PAGE
1	Total Blue Losses	3-2
2	Total Red Losses	3-2
3	Loss Exchange Comparison	3-3
4	Blue Losses by Cause	3-4
5	Red Losses by Cause	3-4
6	Personnel Losses by Blue Units Having Military Activity	3-5
7	Personnel Losses by Red Units Having Military Activity	3-6
8	Blue Artillery Force Comparison	3-7
9	Red Artillery Force Comparison	3-7
10	Blue Artillery Comparison by Weapon Type	3-8
11	Red Artillery Comparison by Weapon Type	3-9
12	Blue Artillery Assessments by Red Target Types	3-9
13	Red Artillery Assessments by Blue Target Types	3-10
14	Red Targets Detected	3-11
15	Blue Targets Detected	3-12
16	Maneuver Units Engaged in Ground Combat	3-13
17	Blue System Losses to Red Direct Fire Weapons	3-14
18	Red System Losses to Blue Direct Fire Weapons	3-14
19	Blue Movement Summary	3-15
20	Red Movement Summary	3-16
21	Force Movement by Unit Type	3-17

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1.0 INTRODUCTION - WEATHER ANALYSIS

This is report number two of an on-going study utilizing DIVWAG, a computer simulation of a Division Level War Game, to determine the significance of varying battlefield parameters; i.e., artillery parameters, troop and equipment mobility parameters, and weather parameters. In report number R-TR-76-008, the first study in the sequence, the random number seed was changed and the results indicate that the overall battle results were unaffected. During this study, weather parameters were varied to simulate:

a. optimum visibility

b. minimum visibility.

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2.0 CONCLUSIONS AND RECOMMENDATIONS

In order to determine the sensitivity of DIVWAG to weather parameter variations, the following extremes were examined:

a. Good weather-maximum visibility, no precipitation

b. Bad weather- minimum visibility with precipitation.

These runs were subjected to detailed analyses of the following:

c. Total Force Losses by Cause

d. Artillery Effectiveness

e. Target Acquisition

f. Ground Combat Engagements

g. Force Movement

A summary of results by category is contained in this report.

2.1 Total Force Losses by Cause

Blue equipment and personnel losses are significantly lower in bad weather (Figure 1). Red losses (Figure 2) are about the same in bad weather, except for trucks and artillery weapons; artillery losses are insignificant with less than 2 systems lost. The significant reduction in Red truck losses is due primarily to a reduction in Blue counterbattery fire during bad weather since the bulk of truck assets are allocated to artillery units. As expected, both Red and Blue personnel and equipment losses caused by artillery and close air support are reduced during bad weather.

2.2 Artillery Effectiveness

Blue artillery is slightly degraded during bad weather (5% fewer rounds) while Red artillery is drastically degraded (35% fewer rounds). Blue 155MM SP's inflict 9% more casualties in bad weather than in good weather, but this is the exception. The only Red artillery weapons doing better in bad weather are the 130MM guns, but this statistic is tempered by the few casualties occuring in both games. The number of counter-battery missions are substantially decreased in bad weather - - 29% for the Blue and 50% for the Red.

2.3 Target Acquisition

Basically, the same targets are acquired in both good and bad weather. Overall, there is also little difference as to time of first detection,

size, type, and activity for the Red targets. Red maneuver units, however, are detected an average of 21 minutes earlier in good weather. The Red sensors' estimate of the size of Blue targets varies significantly from good weather to bad weather.

2.4 Ground Combat Engagements

There are seven battles or engagements between the Red and Blue forces. An engagement in bad weather occurs later than the same engagement in good weather. Although fewer rounds are fired and fewer systems are destroyed by both forces during bad weather, there is actually an improvement in the losses per round fired ratio (23% for Blue and 26% for Red - Figures 17 and 18). There is relatively no change in Blue rounds fired at Red tanks, but there are approximately one-third fewer Red rounds fired at Blue tanks in bad weather.

2.5 Force Movement

The Red force required 13% more time in bad weather than in good weather to advance virtually the same distance. Actually, there was a 1% reduction in ground gained by the Red force in the bad weather games as compared to the good weather game. Also, in bad weather, the Blue force required 7% less time to cover 11% less distance than in good weather.

In conclusion, the model has proven sensitive to different sets of weather parameters. Decreased visibility is more detrimental to the Red attackers than the Blue defenders. It is recommended that this study be followed by a study of such parameters as; extended range artillery performance, suppression time, rate of fire, and lethal areas.

3.0 DISCUSSION

The physical environment of the area of combat operations plays a significant role in the execution of military activities. For this reason, it was decided initially to subject the weather parameters to sensitivity testing. Later in subsequent studies, the parameters mentioned in Section 2. will be conducted. Within DIVWAG, weather conditions are described for each hour of game time in terms of the following parameters:

a. Temperature (in degrees Fahrenheit)

b. Precipitation (none, light, or heavy)

c. Fog (yes or no)

d. Cloud cover (percent)

e. Wind speed (knots)

f. Wind direction (azimuth in degrees)

g. Relative humidity (percent)

h. Visibility index (1-9; 1 worst, 9 best).

The first seven parameters above are established in the pregame phase as a portion of the data load. Additionally, parameters describing moon conditions (quarter, moonrise, and moonset), sun conditions (time for beginning morning nautical twilight (BMNT), and evening nautical twilight (EENT), sunrise and sunset) are also set at this time. The visibility index is determined from the cloud cover, precipitation and fog parameters, and the times of sunset, sunrise, moonrise, and moonset. These weather parameters are used in the Ground Combat, Air/Ground Engagement, Movement, Intelligence and Control, and Engineer Models to represent the impact of weather conditions on line of sight, mobility, weapons effects, etc.

Two weather extremes were examined:

i. Good weather - 10:00 in the morning and maximum visibility

j. Bad weather - 4:00 in the morning and minimum visibility.

These weather differences have been analyzed for:

k. Total Force Losses by Cause

l. Artillery Effectiveness

m. Target Acquisition

n. Ground Combat

o. Movement

Throughout this report GOOD will be used to indicate good weather

and BAD will be used to indicate bad weather.

3.1 Total Force Losses by Cause

Blue and Red force losses for GOOD and BAD are compared in Figures 1 and 2. Blue losses are significantly less during BAD for all categories while Red losses per category are within ± 10%, except for trucks and artillery weapons. There are not enough Red artillery weapons affected to yield any significant results, but there are 42% fewer Red trucks lost in BAD.

CATEGORY	GOOD WEATHER	BAD WEATHER	% DIFF
1. Personnel	668	487	-27
2. Tanks	60.46	44.09	-27
3. Vehicle-mounted antitank guided missiles	14.82	11.09	-25
4. Personnel carriers and other tracked vehicles	48.54	41.69	-14
5. Trucks	187.46	163.55	-13
6. Man-packed antitank guided missiles	54.35	44.98	-17
7. Other antitank weapons	222.05	183.14	-18
8. Artillery weapons	0.35	0.08	-77

Figure 1 Total Blue Losses

CATEGORY	GOOD WEATHER	BAD WEATHER	% DIFF
1. Personnel	2654	2499	-6
2. Tanks	62.20	66.32	+7
3. Vehicle-mounted antitank guided missiles	13.85	13.56	-2
4. Personnel carriers and other tracked vehicles	82.90	86.03	+4
5. Trucks	79.26	46.10	-42
6. Man-packed antitank guided missiles	14.79	13.95	-6
7. Other antitank weapons	139.56	127.52	-9
8. Artillery weapons	1.20	0.82	-32

Figure 2 Total Red Losses

A loss exchange comparison for personnel, tanks, and all other direct fire systems involved is made in Figure 3. An increased Blue force effectiveness is clearly demonstrated during BAD by the exchange loss ratio; i.e.. 18% increase in direct fire systems losses other than tanks, 29% increase in personnel losses, and 46% increase in tank exchange ratios.

	RED LOSSES			BLUE LOSSES			EXCHANGE RATIO (RED/BLUE)		
TYPE WEATHER	PERSONNEL	TANKS	OTHER DIRECT FIRE	PERSONNEL	TANKS	OTHER DIRECT FIRE	PERSONNEL	TANKS	OTHER DIRECT FIRE
GOOD	2654	62.20	250.25	668	60.46	336.91	3.97:1	1.03:1	0.74:1
BAD	2499	66.32	240.52	487	44.09	277.83	5.13:1	1.50:1	0.87:1
% CHANGE	-6	+7	-4	-27	-27	-18	+29	+46	+18

Figure 3 Loss Exchange Comparison

Force losses are summarized by cause in Figures 4 and 5. It can be seen than percentage losses due to Red close air decreases during BAD. It should be noted that except for personnel, Red direct fire weapons are the major cause of Blue losses. From Figure 5, it can be seen that in all categories Blue direct fire weapons inflicted more losses in BAD than in GOOD. Except for personnel, there is little percentage of losses change due to BAD. The discussed personnel losses appear to be the result of less ground combat time.

A breakout of personnel losses by individual Blue and Red units is given in Figures 6 and 7. With respect to blue units, only two units (#213 and #217) are significantly different. During GOOD, #213 received 46 rounds of incoming artillery and suffered 16 casualties but in BAD received only 34 rounds of incoming artillery, suffering 6 casualties. During GOOD, #217 received 72 rounds of counterbattery fire, suffering 69 casualties. No counterbattery fire was received by #217 during BAD.

There are quite a few differences between GOOD and BAD for the Red units. During both GOOD and BAD, artillery units 563, 730, and 806 and maneuver units 677, 682, 693, 709, 759, and 764 finish the period with less than 60% of their original personnel strength. During GOOD only, artillery units 567, 775, and 808 are also under 60% of personnel strength. The military gamers during the original FASCAM[1] game considered 60% the level necessary to maintain unit effectiveness. Under this criterion, only three of the nine maneuver units engaged in ground combat are capable of

MEASURES OF EFFECTIVENESS	LOSSES		PERCENTAGE OF LOSSES		GOOD/BAD
	GOOD	BAD	GOOD	BAD	
1. Blue personnel killed by:					
a. Red direct fire weapons	300	225	.450	.463	1.333
b. Red artillery	321	240	.480	.492	1.338
c. Red close air	45	20	.067	.041	2.250
d. Red air defense	2	2	.003	.004	1.000
TOTAL	668	487			1.372
2. Blue tanks killed by:					
a. Red direct fire weapon	47.46	34.70	.785	.787	1.368
b. Red artillery	6.71	6.97	.111	.158	.963
c. Red close air	6.29	2.42	.104	.055	2.599
TOTAL	60.46	44.09			1.371
3. Blue APC's killed by:					
a. Red direct fire weapons	29.07	24.22	.636	.627	1.200
b. Red artillery	12.75	12.78	.279	.331	.998
c. Red close air	3.88	1.62	.085	.042	2.395
TOTAL	45.70	38.62			1.183
4. Blue veh-mtd ATGM's killed by:					
a. Red direct fire weapons	12.09	8.63	.816	.778	1.401
b. Red artillery	2.22	2.25	.150	.203	.987
c. Red close air	0.51	0.21	.034	.019	2.429
TOTAL	14.82	11.09			1.336

Figure 4 Blue Losses by Cause

MEASUREMENTS OF EFFECTIVENESS	LOSSES		PERCENTAGE OF LOSSES		GOOD/BAD
	GOOD	BAD	GOOD	BAD	
1. Red personnel killed by:					
a. Blue direct fire weapons	1025	1050	.386	.420	.976
b. Blue artillery	1616	1437	.609	.575	1.125
c. Blue helicopters	11	10	.004	.004	1.100
d. Blue air defense	2	2	.001	.001	1.000
TOTAL	2654	2499			1.062
2. Red tanks killed by:					
a. Blue direct fire weapons	53.43	57.70	.859	.870	.926
b. Blue artillery	5.97	6.44	.096	.097	.927
c. Blue helicopters	2.80	2.19		.033	1.279
TOTAL	62.20	66.33			.938
3. Red APC's killed by:					
a. Blue direct fire weapons	69.77	73.43	.853	.861	.950
b. Blue artillery	10.79	10.49	.132	.123	1.029
c. Blue helicopters	1.23	1.36	.015	.016	.904
TOTAL	81.79	85.28			.959
4. Red veh-mtd ATGM's killed by:					
a. Blue direct fire weapons	13.24	12.87	.956	.949	1.029
b. Blue artillery	0.61	0.69	.044	.051	.884
TOTAL	13.85	13.56			1.021

Figure 5 Red Losses by Cause

IUID	UTD	DESCRIPTION	PERSONNEL STRENGHT AT START OF PERIOD	STRENGTH AT END OF PERIOD			
				GOOD	PERCENT	BAD	PERCENT
1	EAFA	155 SP BN HQS	203	191	94	191	94
4	IAFA	155 SP BTY	112	112	100	112	100
5	IAFA	155 SP BTY	112	92	82	92	82
6	IAFA	155 SP BTY	112	112	100	112	100
7*	EMMT	TANK BN MIXED	657	595	91	617	94
14*	FMMI	MEC INF BN	790	705	89	718	91
21*	FMMI	MEC INF BN	872	771	88	780	89
31	IAFA	155 SP BTY	112	112	100	112	100
32	IAFA	155 SP BTY	112	112	100	112	100
33	IAFA	155 SP BTY	112	85	76	85	76
34*	FMMT	TANK BN	657	565	86	577	88
41*	FMMT	TANK BN	657	565	86	584	89
48*	FMMT	TANK BN	554	484	87	496	90
54*	FMMI	MEC INF BN	708	697	99	707	100
92	IZSE	ENGINEER COMPANY	68	68	100	68	100
93	IZSE	ENGINEER COMPANY	68	66	97	66	97
97	IZSE	ENGINEER COMPANY	117	117	100	117	100
104	IBFA	203 SP BTY	112	112	100	112	100
105	IBFA	203 SP BTY	112	112	100	112	100
106	IBFA	203 SP BTY	112	112	100	112	100
110	IAFA	155 SP BTY	112	112	100	112	100
111	IAFA	155 SP BTY	112	112	100	112	100
112	IAFA	155 SP BTY	112	112	100	112	100
144	IAFA	155 SP BTY	112	112	100	112	100
145	IAFA	155 SP BTY	112	112	100	112	100
146	IAFA	155 SP BTY	112	112	100	112	100
185	IAFA	155 SP BTY	112	112	100	112	100
186	IAFA	155 SP BTY	112	112	100	112	100
187	IAFA	155 SP BTY	112	112	100	112	100
205	IGFA	203 SP BTY	102	102	100	102	100
206	IGFA	203 SP BTY	102	102	100	102	100
207	IGFA	203 SP BTY	102	102	100	102	100
211	IGFA	203 SP BTY	102	102	100	102	100
212	IGFA	203 SP BTY	102	102	100	102	100
213	IGFA	203 SP BTY	102	86	84	96	94
217	IHFA	155 TOWED BTY	111	42	38	111	100
218	IHFA	155 TOWED BTY	111	111	100	111	100
219	IHFA	155 TOWED BTY	111	111	100	111	100
264	JSSE	ENG CO	111	111	100	111	100
265	JSSE	ENG CO	111	111	100	111	100
280	IISH	AIR CAV TROOP	169	169	100	169	100
285	CBCH	HELICOPTER PLATOON	24	20	83	22	91
288	UFIJ	MOHAWK	2	2	100	2	100
297	VFIJ	RECON FLIGHT	2	0	0	0	0
298	VFIJ	RECON FLIGHT	2	2	100	2	100
			8733	8068	92.4	8242	94.4

* - Engaged in Ground Combat

Figure 6 Personnel Losses by Blue Units Having Military Activity

IUID	UTD	DESCRIPTION	PERSONNEL STRENGTH AT START OF PERIOD	STRENGTH AT END OF PERIOD			
				GOOD	PERCENT	BAD	PERCENT
516	DRRY	AIR ARMY	2	0	0	0	0
563	MAFA	122 BTY	69	27	39	29	42
565	MAFA	122 BTY	69	69	100	69	100
567	MAFA	122 BTY	69	20	29	49	71
579	MAFA	122 BTY	69	69	100	69	100
677*	GRMI	MR BN+	527	213	40	192	36
682*	GRMI	MR BN+	548	98	18	85	16
693*	GRMI	MR BN+	527	203	39	207	39
709*	GRMI	MR BN+	527	191	36	241	46
719	GRFA	152 BN	315	242	77	308	98
720	HGFA	130 BN	341	341	100	341	100
723	GRFA	152 BN	315	308	98	310	98
724	HGFA	130 BN	341	341	100	341	100
725	GHFA	122 BN	260	149	57	260	100
728	GRFA	152 BN	315	252	80	267	85
729	GHFA	122 BN	260	260	100	260	100
730	GHFA	122 BN	260	149	57	148	57
733	NLFA	MRL BTY	66	66	100	66	100
734	NLFA	MRL BTY	66	66	100	66	100
735	NLFA	MRL BTY	66	66	100	66	100
755	GEMT	TANK BN+	344	343	100	343	100
759*	GEMT	TANK BN+	344	199	58	201	58
764*	GEMT	TANK BN+	365	118	32	88	24
783*	GEMT	TANK BN+	365	316	87	334	92
784	NDFD	57 T BTY	67	67	100	67	100
795*	GEMT	TANK BN+	344	292	85	291	85
800*	GEMT	TANK BN+	365	316	87	289	79
801	NDFD	57 T BTY	67	61	91	67	100
802	GTLT	REAR SERVICES	155	150	97	155	100
806	GHFA	122 BN	260	134	52	85	33
807	GHFA	122 BN	260	246	95	232	89
808	GHFA	122 BN	260	132	51	236	91
811	NLFA	MRL BTY	66	66	100	66	100
812	NLFA	MRL BTY	66	66	100	66	100
813	NLFA	MRL BTY	66	66	100	66	100
881	MRSE	ENGINEER COMPANY	76	76	100	65	86
892	MRSE	ENGINEER COMPANY	76	76	100	76	100
900	GXMT	TANK BN	91	90	99	90	99
903	MRSE	ENGINEER COMPANY	76	76	100	76	100
912	MVFA	FROG SECTION	18	18	100	18	100
916	DBFD	AA REST	272	271	100	271	100
926	MRSE	ENGINEER COMPANY	76	76	100	76	100
935	MRSE	ENGINEER COMPANY	76	76	100	76	100
946	MRSE	ENGINEER COMPANY	76	76	100	76	100
956	GEFA	152 BN	219	219	100	219	100
957	HPFA	130 BN	207	207	100	207	100
960	GRFA	152 BN	315	253	80	274	87
961	HGFD	130 BN	341	341	100	341	100
969	MVFA	FROG SECTION	18	18	100	18	100
			10,343	7,575	73.2	7,843	75.8

* - Engaged in Ground Combat

Figure 7 Personnel Losses by Red Units Having Military Activity

continuing the attack into Period 2.

3.2 Artillery Effectiveness

For reporting purposes, mortar fire has been included with artillery fire.

During BAD, Blue artillery fired 4 % fewer missions, assessed 7% fewer targets, fired 5% fewer total rounds, and inflicted 11% fewer personnel casualties (Figure 8) than during GOOD. Personnel losses/round fired are 6% greater during GOOD. Therefore, Blue artillery performance is not significantly altered due to the weather.

Red artillery fired 28% fewer missions, assessed 20% fewer targets, fired 35% fewer total rounds, and inflicted 25% fewer personnel casualties in BAD (Figure 9). Red artillery's ability to deliver fire is serverely degraded due to poor weather. This is understandable because of the scenario posture of the Blue and Red forces for Period 1 (Red - attacking and Blue - primarily stationary defense).

TYPE WEATHER	MISSIONS FIRED	TARGETS ASSESSED	% MISSIONS ASSESSED	ROUNDS FIRED	PERSONNEL CASUALTIES INFLICTED	PERSONNEL LOSSES/ ROUND FIRED
GOOD	1150	892	78	6690	1621	0.242
BAD	1106	828	75	6333	1440	0.227
% CHANGE	-4	-7	-4	-5	-11	-6

Figure 8 Blue Artillery Force Comparison

TYPE WEATHER	MISSIONS FIRED	TARGETS ASSESSED	% MISSIONS ASSESSED	ROUNDS FIRED	PERSONNEL CASUALTIES INFLICTED	PERSONNEL LOSSES/ ROUND FIRED
GOOD	538	275	51	8528	322	0.038
BAD	390	220	56	5539	241	0.044
% CHANGE	-28	-20	+10	-35	-25	+16

Figure 9 Red Artillery Force Comparison

Comparisons of Blue and Red artillery are made by weapon type in Figures 10 and 11. Note that for Blue the 155MM SP weapons are unaffected by the weather extremes as far as total missions fired and total rounds fired; consequently, the 155MM SP percentage of total force rounds is up 2.5% in BAD. Total mortar rounds are decreased 2.5% in BAD. The 155MM Towed and 203MM SP weapons fire fewer rounds in BAD and have a substantial decrease in the personnel losses/round fired ratio.

Note that no Red mortars were fired in BAD. In DIVWAG, mortars are organic to those units involved in ground combat. The priorities of fire, as determined by the Red gamers, is to use artillery as the primary method of attack. If insufficient artillery is available, the units' organic mortars are used. Due to a 35% reduction in the amount of Red artillery rounds fired in BAD, mortars never had to be used. The 130MM guns did appreciably better in BAD than in GOOD as far as % of missions assessed and personnel losses/rounds fired.

WEAPON TYPE	WEATHER TYPE	MISSIONS FIRED	TARGETS ASSESSED	% MISSIONS ASSESSED	ROUNDS FIRED	PERSONNEL CASUALTIES INFLICTED	PERSONNEL LOSSES/ ROUND FIRED	% TOTAL ROUNDS FIRED
81MM MORTAR	GOOD	4	4	100	148	21	0.142	2.2
	BAD	3	3	100	91	17	0.187	1.4
% CHANGE		-25	-25	0	-39	-19	+32	
107MM MORTAR	GOOD	20	20	100	657	134	0.234	9.8
	BAD	17	17	100	510	117	0.229	8.1
% CHANGE		-15	-15	0	-22	-24	-2	
155MM SP	GOOD	584	445	76	3496	714	0.204	52.3
	BAD	579	442	76	3468	780	0.225	54.8
% CHANGE		-1	-1	0	-1	+9	+10	
155MM TOWED	GOOD	149	128	86	857	298	0.348	12.8
	BAD	133	101	76	798	189	0.237	12.6
% CHANGE		-11	-21	-12	-7	-37	-32	
203MM SP	GOOD	393	295	75	1532	434	0.283	22.9
	BAD	374	265	71	1466	337	0.230	23.1
% CHANGE		-5	-10	-5	-4	-22	-19	

Figure 10 Blue Artillery Comparison by Weapon Type

WEAPON TYPE	WEATHER TYPE	MISSIONS FIRED	TARGETS ASSESSED	% MISSIONS ASSESSED	ROUNDS FIRED	PERSONNEL CASUALTIES INFLICTED	PERSONNEL LOSSES/ ROUND FIRED	% TOTAL ROUNDS FIRED
120MM MORTAR	GOOD	27	27	100	1341	13	0.010	15.7
	BAD	0	0		0	0		0.0
% CHANGE								
122MM HOWITZER	GOOD	255	137	54	3464	77	0.022	40.6
	BAD	193	102	53	2457	52	0.021	44.4
% CHANGE		-24	-26	-2	-29	-32	-4	
122MM RL	GOOD	19	13	68	79	68	0.861	0.9
	BAD	13	8	62	73	59	0.808	1.3
% CHANGE		-32	-31	-9	-8	-11	-6	
152MM GUN/HOW	GOOD	121	55	45	1956	125	0.064	22.9
	BAD	103	58	56	1683	80	0.048	30.4
% CHANGE		-15	+5	+24	-14	-36	-25	
130MM GUN	GOOD	104	43	41	1686	39	0.023	19.8
	BAD	81	52	64	1326	49	0.037	23.9
% CHANGE		-22	+21	+56	-21	+26	+61	
FROG	GOOD	2	0	0	2	0		0.0
	BAD	0	0	0	0	0		
% CHANGE								

Figure 11 Red Artillery Comparison by Weapon Type

Assessments as a function of target type are listed in Figures 12 and 13. As expected, there is a significant decrease in counterbattery fire (29% for Blue artillery and 50% for Red artillery) in BAD.

RED TARGET DESCRIPTION	NUMBER OF ASSESSMENTS		% DIFFERENCE
	GOOD	BAD	
MOTORIZED RIFLE BN+	364	355	-2
TANK BN+	356	357	-
57 AIR DEFENSE BTY	6	0	
REAR SERVICES	6	0	
122 HOW BN	68	60	-12
122 HOW BTY	19	15	-21
AA REGT	3	3	0
TANK BN-	3	3	0
152 GUN HOW BN	67	34	-49
ENGINEER CO.	0	1	
TOTAL	892	828	-7

Figure 12 Blue Artillery Assessments by Red Target Types

BLUE TARGET DESCRIPTION	NUMBER OF ASSESSMENTS		% DIFFERENCE
	GOOD	BAD	
MEC BN	113	80	-29
TANK BN A-2	33	22	-33
BRIGADE HQ	10	10	0
TANK BN A-3	105	100	-5
ENGINEER CO	2	2	0
155MM SP BTY	2	2	0
155MM SP BN HQ	2	2	0
203MM SP BTY	4	2	-50
155MM TOWED BTY	4	0	
TOTAL	275	220	-20

Figure 13 Red Artillery Assessments by Blue Target Types

3.3 Target Acquisition

The targets acquired are compared in Figures 14 and 15. Basically, there is little difference as to time of first detection, size, type, and activity for the Red targets. There is a substantial difference in the time of last detection. With the exception of #806 (an artillery battalion), the only units affected are the maneuver units engaged in ground combat. These maneuver units are detected an average of 21 minutes earlier in GOOD than in BAD.

The Red forces estimated size of the Blue targets varies quite a bit from GOOD to BAD. There are 40 Blue and 11 Red sensor reports in BAD.

The number of Red close air sorties was reduced from 16 in GOOD to 8 in BAD. There were 6 Blue attack helicopter sorties in both GOOD and BAD.

TGTID	TIME OF FIRST DETECTION (MIN)		ESTIMATED SIZE		ESTIMATED TYPE		ESTIMATED ACTIVITY		TIME OF LAST DETECTION (MIN)		ESTIMATED SIZE		ESTIMATED TYPE		ESTIMATED ACTIVITY	
	GOOD	BAD	GOOD	BAD	GOOD	BAD	GOOD	BAD	GOOD	BAD	GOOD	BAD	GOOD	BAD	GOOD	BAD
535	4	4	PLT+	PLT+	ADA-MSL	ADA-MSL	STAY	STAY								
536	4	4	PLT+	PLT+	ADA-MSL	ADA-MSL	STAY	STAY								
537	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
540	4	4	PLT+	PLT+	ADA-MSL	ADA-MSL	STAY	STAY								
562	4	-	PLT	-	ADA-MSL	-	STAY	-								
563	25	25	CO	CO	ARTY TUBE	ARTY TUBE	FIRING	FIRING								
567	26	8	CO	CO	ARTY TUBE	ARTY TUBE	FIRING	FIRING								
581	4	-	PLT	-	ADA-MSL	-	STAY	-								
606	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
610	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
615	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
623	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
627	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
632	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
640	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
644	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
649	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
662	-	4	-	PLT	-	ADA-MSL	-	STAY								
673	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
677	4	4	CO	CO	CP	CP	DEFEND	DEFEND	47	70	CO	PLT+	REINF TF	MECH INF	ATTACK	ATTACK
682	4	4	PLT	PLT	ADA-MSL	ADA-MSL	DEFEND	DEFEND	33	44	PLT	PLT	MECH INF	MECH INF	ATTACK	ATTACK
689	4	4	CO	CO	CP	CP	DEFEND	STAY								
693	4	4	CO	CO	CP	CP	DEFEND	DEFEND	19	71	CO	BN	REINF TF	REINF TF	ATTACK	ATTACK
698	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
705	4	4	PLT	PLT	ADA-MSL	ADA-MSL	DEFEND	DEFEND								
709	4	4	CO	CO	CP	CP	DEFEND	DEFEND	15	54	CO	CO	REINF TK	CP	ATTACK	ATTACK
714	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
719	39	13	CO+	CO+	ARTY TUBE	ARTY TUBE	FIRING	FIRING								
728	33	34	CO+	CO+	ARTY TUBE	ARTY TUBE	FIRING	FIRING								
730	12	26	CO+	CO+	ARTY TUBE	ARTY TUBE	FIRING	FIRING								
755	4	4	PLT	PLT	ARTY TUBE	ADA-MSL	STAY	STAY								
759	4	4	CO	CO	CP	CP	DEFEND	DEFEND	28	31	CO+	CO+	REINF TF	REINF TF	ATTACK	ATTACK
764	4	4	PLT	PLT	ADA-MSL	ADA-MSL	DEFEND	DEFEND	53	70	CO	BN+	CP	REINF TF	ATTACK	ATTACK
770	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
774	-	4	-	PLT	-	ADA-MSL	-	STAY								
778	-	4	-	PLT	-	ADA-MSL	-	STAY								
783	4	4	PLT	PLT	ADA-MSL	ADA-MSL	DEFEND	DEFEND	15	44	CO+	PLT+	REINF TF	ARMOR	ATTACK	ATTACK
784	4	-	CO	-	CP	-	MOVING	-								
791	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
795	4	4	CO	CO	CP	CP	DEFEND	DEFEND	60	70	CO	CO	REINF TF	REINF TF	ATTACK	ATTACK
800	4	4	PLT	PLT	ADA-MSL	ADA-MSL	DEFEND	DEFEND	10	19	BN+	BN+	REINF TK	REINF TF	ATTACK	DEFEND
806	12	54	CO+	CO+	ARTY TUBE	ARTY TUBE	FIRING	FIRING	42	54	CO	CO+	CP	ARTY TUBE	FIRING	STAY
808	17	17	CO+	CO+	ARTY TUBE	ARTY TUBE	FIRING	FIRING								
834	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
845	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
857	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
868	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
916	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
937	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
949	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								
960	13	13	CO+	CO+	ARTY TUBE	ARTY TUBE	FIRING	FIRING								
973	4	4	PLT	PLT	ADA-MSL	ADA-MSL	STAY	STAY								

Figure 14 Red Targets Detected

TGT ID	TIME OF FIRST DETECTION (MIN)		ESTIMATED SIZE		ESTIMATED TYPE		ESTIMATED ACTIVITY		TIME OF LAST DETECTION (MIN)		ESTIMATED SIZE		ESTIMATED TYPE		ESTIMATED ACTIVITY	
	GOOD	BAD	GOOD	BAD	GOOD	BAD	GOOD	BAD	GOOD	BAD	GOOD	BAD	GOOD	BAD	GOOD	BAD
5	8	8	CO	CO	ARTY TUBE	ARTY TUBE	FIRING	FIRING								
7	65	66	BDE	CO	REINF TF	REINF TF	DEFEND	DEFEND								
14	69	71	BDE	CO	REINF TF	REINF TF	DEFEND	DEFEND								
21	70	65	BDE	CO+	MECH INF	MECH INF	DEFEND	DEFEND								
33	7	7	CO	CO	ARTY TUBE	ARTY TUBE	FIRING	FIRING								
34	70	60	BDE	CO	REINF TF	REINF TF	DEFEND	DEFEND	-	70	-	CO	-	REINF TF	-	DEFEND
41	70	70	BDE	CO+	REINF TF	REINF TF	DEFEND	DEFEND								
48	63	31	BDE	BN	REINF TF	REINF TF	DEFEND	DEFEND	-	66	-	CO	-	ARMOR	-	DEFEND
217	22	22	CO	CO	ARTY TUBE	ARTY TUBE	FIRING	FIRING								

Figure 15 Blue Targets Detected

3.4 Ground Combat Engagements

There are seven battles or engagements betweeen the Red and Blue Force in the two hour game described by this report. These battles are summarized in Figure 16.

FORCE TYPE	IUID	MOVEMENT (METERS)		BATTLE ID	
		GOOD	BAD	GOOD	BAD
BLUE	7	923	0	1-1A	1
RED	709	4025	3567	1-1A	1
BLUE	14	916	538	2-2A	2
RED	693	4038	3924	2-2A	2
BLUE	21	2150	500	3-3A	3
RED	682	1580	1257	3-3A	3
BLUE	34	4201	4860	4-4A	4-4A
RED	677	1342	2769	4-4A	4-4A
RED	800	1152	1152	4-4A	4-4A
BLUE	54	0	0	5	5
RED	783	4885	4887	5	5
RED	795	1971	1971	5	5
BLUE	41	3307	1989	6-6A	6-6A
RED	764	3217	2575	6-6A	6-6A
BLUE	48	4173	2693	7-7A	7-7A
RED	759	4077	3514	7-7A	7-7A

Figure 16 Maneuver Units Engaged in Ground Combat

Battles suffixed with the letter "A", (involves the withdrawal of the Blue units) occur when the involved Blue unit's personnel strength drops below 90%. Note that some of the "A" battles (1A, 2A, and 3A) are not consumated in BAD. This is due to:

a. Fewer personnel losses in BAD, and/or

b. Degradation of movement rates in BAD.

Blue and Red systems (direct fire weapons only) lost by maneuver units engaged in ground combat are tabulated in Figures 17 and 18. An engagement in BAD occurs later than the same engagement in GOOD and

usually with the combatants being nearer each other. Thus, although fewer rounds are fired and fewer systems killed by both forces in BAD, there is actually an improvement in the loss per round fired ratio (+23% for Blue and +26% for Red). There is relatively no change in Blue rounds fired at Red tanks, regardless of weather. The loss exchange ratio (Blue/Red) was 0.483 (88.029/182.089) in GOOD and 0.395 (66.851/169.319) in BAD. This is an increase of 18% in Blue effectiveness during BAD.

WEATHER TYPE	MAN PACKED ATGM			VEH MTD ATGM			TANKS			APCS			TOTAL SYSTEMS		
	LOSSES	RED ROUNDS FIRED	RATIO	LOSSES	RED ROUNDS FIRED	RATIO	LOSSES	RED ROUNDS FIRED	RATIO	LOSSES	RED ROUNDS FIRED	RATIO	LOSSES	RED ROUNDS FIRED	RATIO
GOOD	.193	66.92	.0029	11.886	186.78	.0636	47.257	471.11	.1003	28.693	570.17	.0503	88.029	1294.98	.0680
BAD	.157	39.36	.0040	8.418	111.16	.0757	34.472	293.06	.1176	23.804	353.35	.0674	66.851	796.93	.0839
PERCENT	-19	-41	+38	-29	-40	+19	-27	-38	+17	-17	-38	+34	-24	-38	+23

Figure 17 Blue Systems Losses to Red Direct Fire Weapons

WEATHER TYPE	MAN PACKED ATGM			VEH MTD ATGM			TANKS			APCS			TOTAL SYSTEMS		
	LOSSES	BLUE ROUNDS FIRED	RATIO	LOSSES	BLUE ROUNDS FIRED	RATIO	LOSSES	BLUE ROUNDS FIRED	RATIO	LOSSES	BLUE ROUNDS FIRED	RATIO	LOSSES	BLUE ROUNDS FIRED	RATIO
GOOD	46.380	395.20	.1174	13.028	54.15	.2406	53.296	240.12	.2220	69.385	468.64	.1481	182.089	1158.11	.1572
BAD	26.138	215.78	.1211	12.610	36.51	.3453	57.494	234.16	.2455	73.077	371.79	.1966	169.319	858.24	.1973
PERCENT	-44	-45	+3	-3	-33	+44	+8	-2	+11	+5	-21	+33	-7	-26	+26

Figure 18 Red System Losses to Blue Direct Fire Weapons

3.5 Force Movement

Blue and Red individual unit movements are tabulated in Figures 19 and 20. The Blue force had a total movement of 110,005 meters in 862.58 minutes in GOOD and 97,619 meters in 805.66 minutes in BAD. This represents a 11% decrease in distance moved in 7% less elapsed time. The Red force had a total movement of 113,960 meters in 1123.48 minutes and 112, 828 meters in 1274.88 minutes in Good and Bad respectively. This implies a 13% greater elapsed time to move 1% less distance.

A breakout of force movement by unit types in given in Figure 21. Analysis of this figure shows a definite advantage for the Blue defense during BAD (much less movement by the direct support artillery batteries and the maneuver units engaged in ground combat).

UID	IUID	UTD	DISTANCE (METERS)	GOOD		BAD		
				TIME ELAPSED (MINUTES)	AVE. VELOCITY (KM/HR)	DISTANCE (METERS)	TIME ELAPSED (MINUTES)	AVE. VELOCITY (KM/HR)
B255DSIC	6	IAFA	1092	3.00	21.84	NONE	-	-
B111BNAR	7	EMMT	923	115.00	0.48	NONE	-	-
B120M1BN	14	FMMI	916	106.47	0.52	538	101.97	0.32
B130M1BN	21	FMMI	2150	111.36	1.16	500	111.82	0.27
B255DS2A	31	IAFA	7436	20.41	21.86	7436	27.25	16.37
B255DS2C	33	IAFA	7665	21.06	21.84	2115	7.75	16.37
B100ARBN	34	FMMT	4201	92.49	2.73	4860	113.32	2.57
B101ARBN	41	FMMT	3307	112.74	1.76	1989	113.66	1.05
B102ARBN	48	FMMT	4173	97.65	2.56	2693	94.42	1.71
B2ENGACO	92	IZSE	4365	13.80	18.98	NONE	-	-
B2ENGBCO	93	IZSE	7978	18.78	25.49	7978	26.33	18.18
B1ENGDCO	97	IZSE	12565	32.73	23.03	12565	48.08	15.68
BCENGACO	264	JSSE	5474	14.64	22.43	5474	21.74	15.11
BCENGBCO	265	JSSE	5508	13.24	24.96	5508	18.75	17.63
BBBB0310	310	PCSE	1389	3.05	27.32	1389	3.82	21.82
BBBB0311	311	PCSE	353	0.72	29.42	353	0.89	23.80
BBBB0312	312	PCSE	2293	4.72	29.15	2293	5.82	23.64
BBBB0313	313	PCSE	570	1.25	27.36	570	1.56	21.92
BBBB0316	316	PCSE	3803	8.15	28.00	3803	10.13	22.53
BBBB0317	317	PCSE	9453	19.92	28.47	9453	24.68	22.98
BBBB0318	318	PCSE	7646	16.37	28.02	7646	20.33	22.57
BBBB0319	319	PCSE	1882	4.14	27.28	1882	5.17	21.84
BBBB0320	320	PCSE	3639	7.49	29.15	3639	9.22	23.68
BBBB0321	321	PCSE	4511	9.35	28.95	4511	11.52	23.49
BBBB0322	322	PCSE	5662	11.89	28.57	5662	14.70	23.11
BBBB0332	332	PCSE	1051	2.16	29.19	1051	2.66	23.71
BBBB0333	333	PCSE	NONE	-	-	1940	5.33	21.84
BBBB0334	334	PCSE	NONE	-	-	1771	4.74	22.42

Figure 19 Blue Movement Summary

UID	IUID	UTD	GOOD			BAD		
			DISTANCE (METERS)	TIME ELAPSED (MINUTES)	AVE. VELOCITY (KM/HR)	DISTANCE (METERS)	TIME ELAPSED (MINUTES)	AVE. VELOCITY (KM/HR)
R5320ZMI	677	GRMI	1342	90.00	0.89	2769	110.00	1.51
R5310ZMI	682	GRMI	1580	110.00	0.86	1257	110.00	0.69
R5220ZMI	693	GRMI	4038	110.00	2.20	3924	111.34	2.11
R5120ZMI	709	GRMI	4025	102.60	2.35	3567	111.98	1.91
RF3X13FA	723	GRFA	16758	30.38	33.10	16758	50.90	19.75
R1320ZTK	759	GEMT	4077	107.95	2.27	3514	108.47	1.94
R1310ZTK	764	GEMT	3217	110.00	1.75	2575	110.00	1.40
R1210ZTK	783	GEMT	4885	71.51	4.10	4887	74.79	3.92
R16020AD	784	NDFD	7210	14.35	30.15	7210	24.16	17.91
R1120ZTK	795	GEMT	1971	60.00	1.97	1971	60.00	1.97
R16010AD	801	NDFD	8064	14.92	32.43	8064	25.06	19.31
R11500RS	802	GTLT	8064	14.92	32.43	8064	25.06	19.31
R53030EN	881	MRSE	4501	25.28	10.68	4502	32.36	8.35
R52030EN	892	MRSE	4123	28.91	8.56	4123	34.36	7.20
R51030EN	903	MRSE	2001	9.99	12.02	2001	11.99	10.01
R13030EN	926	MRSE	12618	72.88	10.39	12618	90.69	8.35
R12030EN	935	MRSE	16487	98.47	10.05	16025	120.00	8.01
R11030EN	946	MRSE	8999	51.32	10.52	8999	63.72	8.47

Figure 20 Red Movement Summary

FORCE	UNIT TYPE	DISTANCE (METERS)		% DIFFERENCE	TIME ELAPSED (MINUTES)		% DIFFERENCE
		GOOD	BAD		GOOD	BAD	
BLUE	ARTILLERY	16193	9551	-41	44.47	35.00	-21
	ARMOR & MECH	15670	10580	-33	635.71	535.19	-16
	ENGINEER	78142	77488	-1	182.40	235.47	+29
RED	ARMOR & MECH	33199	32528	-2	776.98	821.64	+6
	ARTILLERY	16758	16758	0	30.38	50.90	+68
	AIR DEFENSE	15274	15274	0	29.77	49.22	+68
	ENGINEER	48729	48268	-1	286.85	353.12	+23

Figure 21 Force Movement by Unit Type

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Sensitivity of DIVWAG to Variations
in Weather Parameters

Prepared by: Jerry W. Frantz, George E. Stiles
CPT Michael A. Roddy III, William A. Werker
Security Class. (of this report): Unclassified
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2. War Game
3. Simulation
4. Mathematical Model

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This is the second in a continuing series of reports on the application of DIVWAG at Rodman Laboratory. The first report primarily examines the model and its operational utilization at Rodman Laboratory. In this report, the sensitivity of the DIVWAG model to extreme cahnges in the weather environment is evaluated. Two extremes were examined: (1) optimum weather - clear daylight with no precipitation and (2) minimum weather - dark with heavy precipitation. These extremes were evaluated to determine the impact of weather variations on the target acquisition process and the mobility of maneuver units as simulated in the DIVWAG model.

UNCLASSIFIED

1. DIVWAG
2. War Game
3. Simulation
4. Mathematical Model

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Sensitivity of DIVWAG to Variations
in Weather Parameters

Prepared by: Jerry W. Frantz, George E. Stiles
CPT Michael A. Roddy III, William A. Werker
Security Class. (of this report): Unclassified
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